

HP Turbine Design Info  
Alstom

#### INTERMOUNTAIN HP TURBINE RETROFIT

##### 1. Assessment of Interfacing Systems

The contract with ALSTOM Power for the HP turbine retrofit includes for assessment of the following steam turbine auxiliary systems to ensure safe and efficient operation of the HP turbine retrofit:

- Gland steam sealing system
- Turbine drains system
- Lubricating oil system
- Governor and control system
- Instrumentation and protection equipment

The contract includes for essential modifications to the steam turbine governing system to facilitate operation in full arc admission mode. Assessments of the remaining steam turbine auxiliary systems listed above are not expected to reveal any essential modifications specifically to permit safe and efficient operation of the HP turbine retrofit equipment. No allowance is included under the contract for any additional modifications or rectifications of steam turbine auxiliary systems.

The boiler main steam flow and steam conditions at other interfaces with the HP turbine as identified in (2) below will be established at the start of the HP turbine retrofit contract. It is anticipated that IPSC may require the services of a boiler supplier/consultant to assess what modifications (if any) are required to the existing boilers to achieve the increased main steam flow at the nominated terminal conditions. ALSTOM Power, under the HP turbine retrofit contract, will assist IPSC by providing information on revised cycle conditions at boiler interfaces.

It is also anticipated that IPSC may wish to contract with other equipment suppliers/consultants to assess the need for modifications to other plant systems to permit operation with increased steam mass flow and increased electrical output (e.g. generator, boiler feed pumps, boiler feed pump turbines, feedwater heaters). Under the HP turbine retrofit contract, ALSTOM Power will assist IPSC in these studies by providing information on revised cycle conditions at interfaces with other equipment.

##### 2. Definition of Thermodynamic Design Requirements

In order to ensure delivery of the HP turbine retrofit to the Intermountain site in advance of the March 2002 installation outage, design work has already started in order to provide definitions for purchasing the major castings and rotor forging. Definition of these major components necessitates establishing steam path details requiring confirmation of thermodynamic design data. The majority of these data have already been advised, as follows:

Main steam flow                      6.9 Mlb/h at 2400 psig/1000 °F

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HP valve pressure drop            3% (derived from information  
supplied by IPSC)  
Steam admission arrangement    Full arc admission  
HP exhaust pressure            Derived from information supplied  
by IPSC on the basis that the IP  
capacity has been confirmed  
unchanged.

The only item outstanding which IPSC must define *as soon as possible* is the HP turbine extraction pressure. Information has already been provided to illustrate the effect of varying the extraction pressure on final feedwater temperature and on HP shaft power, unit output and unit heat rate. It is anticipated that IPSC will fix the HP turbine extraction pressure (i.e. from after HP Stage 4 or after HP Stage 5) by Friday 19 January, 2001. If IPSC requires any further advice in making this choice, ALSTOM Power will be pleased to assist.

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INTERMOUNTAIN POWER SERVICE CORPORATION  
RESPONSE TO TELECON QUESTIONS OF 3 JANUARY 2001

- Q.1 Please provide information indicating the effect on cycle parameters of moving the HP steam path extraction to the final feedwater heater one stage upstream (from after Stage 5 to after Stage 4).

Response

Please find attached two diagrams indicating the effect of moving the extraction from after HP Stage 5 (Figure 12A) to after HP Stage 4 (Figure 12B). Note that Figure 12A is based on Figure 12 from Section 5 of the ALSTOM Power proposal with additional data added.

The two diagrams allow comparison of extraction steam pressure, temperature, enthalpy, mass flow and volumetric flow together with comparisons of final feedwater temperatures, HP exhaust pressure and temperature, HP shaft power and unit output and heat rate for the two steam extractions.

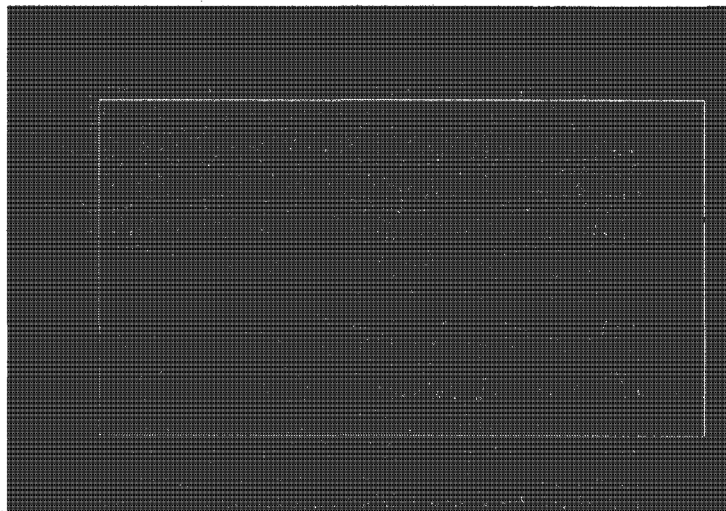
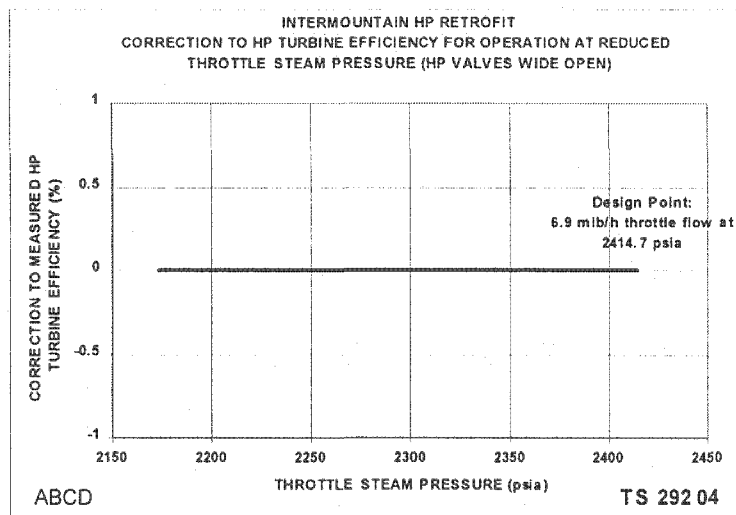
It will be noted the steam mass flow extracted to the top heater at higher pressure increases by just over 25% whilst the specific volume reduces by only 9%. The net effect is to increase the volumetric flow rate to the top heater by approximately 15%. IPSC is advised to consult the original supplier of the HP feedwater heater to assess whether it can be operated safely with increased steam pressure and increased steam velocity.

It will also be noted that the overall reduction in unit output is only 16.5 MW (not the 23 MW stated in the phone call). This value is based on using the same heater TTDs in both cases and now takes into account the variation in bled steam pipe pressure drops with increased extraction steam flow.

ALSTOM Power confirms that the change in steam extraction position can be accommodated mechanically in the steam turbine design. If desired, it would also be possible to redesign the HP turbine retrofit offered to provide an intermediate steam extraction pressure (e.g. to minimize the increase in extraction steam pressure/velocity).

The data provided on Figures 12A and 12B are for information only. ALSTOM Power would be prepared to formulate new performance guarantees corresponding to the revised extraction arrangement or to a different agreed arrangement.

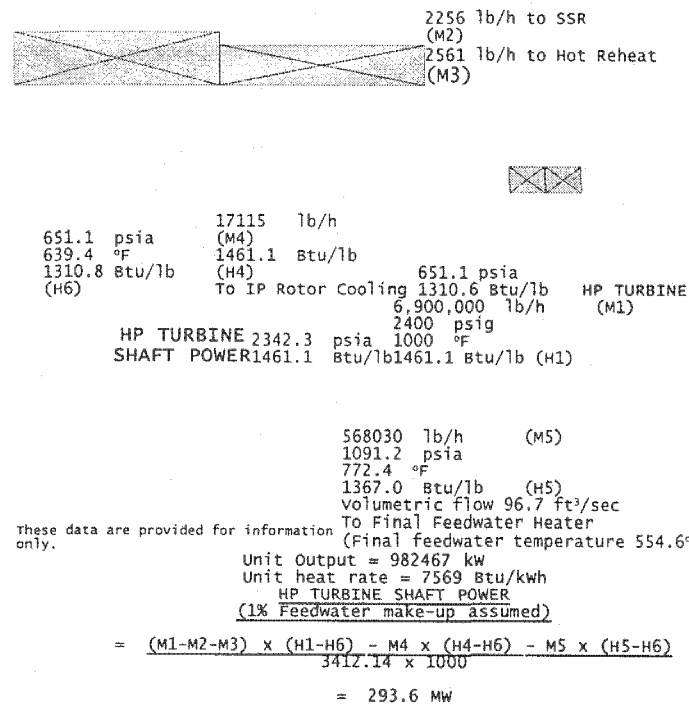
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Figure 12A

HP TURBINE RETROFIT  
DERIVATION OF HP SECTION EFFICIENCY AND SHAFT POWER  
(FINAL FEEDWATER EXTRACTION FROM AFTER HP STAGE 5)



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HP TURBINE EFFICIENCY  
including Valves  
(1997 Steam Tables)


$$\frac{H1 - H6}{H1 - H6'} \times 100 = 92.4 \%$$

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Figure 12b

HP TURBINE RETROFIT  
DERIVATION OF HP SECTION EFFICIENCY AND SHAFT POWER  
(FINAL FEEDWATER EXTRACTION FROM AFTER HP STAGE 4)





636.8 psia	17115 lb/h		
634.0 °F	(M4)		
1308.5 Btu/lb	1461.1 Btu/lb		
(M6)	(H4)		
	To IP Rotor Cooling	636.8 psia	
		1308.3 Btu/lb	HP TURBINE
		6,900,000 lb/h	(M1)
		2400 psig	
HP TURBINE	2342.3 psia	1000 °F	
SHAFT POWER	1461.1 Btu/lb	1461.1 Btu/lb (H1)	

The above data are provided for information only.

713372 lb/h (M5)  
 1222.7 psia  
 804.2 °F  
 1380.4 Btu/lb (H5)  
 Volumetric flow 111.0 ft³/sec  
 To Final Feedwater Heater  
 (Final feedwater temperature 568.4°F)  
 Unit Output = 965897 kw  
 Unit heat rate = 7565 Btu/kwh

$$\begin{aligned} & \text{HP TURBINE SHAFT POWER} \\ & \text{(1\% Feedwater make-up assumed)} \\ & = \frac{(M1-M2-M3) \times (H1-H6) - M4 \times (H4-H6) - M5 \times (H5-H6)}{3412.14 \times 1000} \\ & = 292.5 \text{ MW} \end{aligned}$$

$$\begin{aligned} & \text{HP TURBINE EFFICIENCY} \\ & \text{Including Valves} \\ & \text{(1997 Steam Tables)} \\ & = \frac{H1 - H6}{H1 - H6'} \times 100 = 92.4 \% \end{aligned}$$